DEPARTMENT OF HEALTH

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No. 68 REPRINT SERIES FEBRUARY, 1918

# CLASSROOM VENTILATION AND RESPIRATORY DISEASES AMONG SCHOOL CHILDREN

BY

S. JOSEPHINE BAKER, M. D., D. P. H.

NEW YORK

*Director, Bureau of Child Hygiene, Department of Health*

*"Public health is purchasable. Within natural limitations a community can determine its own death rate."*

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# CLASSROOM VENTILATION AND RESPIRATORY DISEASES AMONG SCHOOL CHILDREN.

S. JOSEPHINE BAKER, M. D., D. P. H.,
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Read before the Sociological Section of the American Public Health Association, October 20, 1917, at Washington, D. C.

THE relationship between the health of school children and the methods of ventilation in classrooms is a matter of sufficient importance to warrant the obtaining of exact statistical data upon which to base our opinions as to the value of either the open air or the mechanical type of ventilation. The value of fresh air in the prevention or in the treatment of certain types of infectious diseases has been recognized for many years. The literature on the subject, however, bears mainly upon the affirmative side of the case or the results of treatment carried on out of doors or in buildings with open window ventilation. There are few, if any, control studies showing the effects upon similar people treated under similar conditions, in closed rooms or in rooms with mechanical types of ventilation.

For many years we have had a controversy between the advocates of these two types of ventilating systems, with particular reference to their use in schoolrooms. In order to obtain definite data upon this point, the Bureau of Child Hygiene of the Department of Health of New York City began in February, 1916, an inquiry into the possible relationship between the prevalence of respiratory diseases among school children and classroom ventilation. This study was made in coöperation with the New York State Commission on Ventilation, which had full control of the selection of classrooms with reference to the type of ventilation to be included, the preparation of forms for recording observations relating to ventilation, the supervision of methods used in obtaining all data concerning ventilation, and the final checking up and analysis of the data on ventilation. The Bureau of Child Hygiene had supervision of all other details of the plan.

There is no intention in this short statement of giving the full analysis of the various points brought out in the study; the purpose is rather to present the conclusions and those specially interested will have an opportunity to review the entire study which will be published within a short time.

This inquiry consisted of two complete studies. Because of the necessity of having closed windows for the proper operation of the mechanical ventilating systems and on account of the usual prevalence of the respiratory diseases during the colder months of the year, it was determined to have the study cover the period from November to April. The first period of observation lasted from February 19, 1916, to April 8, 1916. These dates covered the time between the opening of the second school term and the

advent of spring weather. The second study began with the advent of cold weather and covered the period to the end of the first school term—November 4, 1916, to January 27, 1917.

These two periods were selected first, because of the change of the children from the classrooms studied, due to promotion at the end of the term, and, second, so that the same classrooms might be used with an entirely different group of children of the same age. In 1916, eight schools were studied and in 1916–1917 twelve schools were selected. The general type of children under observation included those of Russian, Italian, Irish and American descent, and of a social status that ranged from the well-to-do who live in comfortable homes, in sanitary surroundings, to the extremely poor, shiftless and ignorant type, where the children receive no home supervision or hygienic care.

For the study of 1916 2,541 children were under observation, and for the 1916–1917 study 2,992 children were observed. The children ranged from the 2B to the 6A grades, and eighty-six per cent were from eight to eleven years of age. These children were grouped in fifty-eight classrooms in 1916 and seventy-six classrooms in the study of 1916–1917.

The children covered by these two studies were of the same age, from the same localities and of the same nationalities but an entirely different group was studied each time.

It was decided that three types of ventilation should form the basis of the study: first, *Type A*. These were the so-called cold, open-window classrooms, ventilated by natural means. It was the desire to have the temperature kept at 50 degrees F. This, however, was found to be impossible owing to variations in the weather, and it therefore ranged from 50 to 60 degrees and occasionally higher. *Type B*. These were moderate temperature classrooms, kept between 60 and 70 degrees F., averaging about 68 degrees F. Ventilation was wholly by open windows. Some rooms had gravity exhaust ducts while others did not. Window deflectors were used in only one room in the 1916 study while in the 1916–1917 study window deflectors were installed and used in all rooms. *Type C*. These rooms were of the same moderate temperature as in Type B, that is, averaging 68 degrees F. Ventilation of the classrooms was by the plenum fan system installed in the buildings, the windows in these classrooms being kept closed.

This board classification of two types of classrooms with open window ventilation and one type with closed windows, ventilated mechanically, was determined upon in order to make the methods more easily controlled and to furnish a usable basis of comparison. No attempt was made to include finer subdivisions based upon minor types of difference in the ventilating systems as it was obvious that the introduction of so many different factors would needlessly complicate the findings and it would be difficult to show their relation to the results.

The field work was under the direct supervision of nine nurses in the 1916 study and fourteen nurses in the 1916–1917 study. Effort was made to have different observers on duty in the different studies so that the results

might not be influenced by the personal equation. Each nurse was in charge of the study in a definite number of classrooms. This number varied from three to eight for each nurse. Records were made at each school session of absences from all causes, absences from sickness other than respiratory, absences due to respiratory sickness, respiratory sickness occurring among pupils in attendance at school, temperature of classrooms at each school session, humidity of classrooms at each school session, and sensations of observers at each school session as to temperature, moisture, odor and air motion in the classroom.

At the beginning of each study each pupil under observation was physically examined by a physician. This examination was supplemented by home visits by the nurse to obtain data relative to home and social conditions.

The daily routine of the nurse was as follows: Each classroom was visited in the morning and in the afternoon. First, the absence records of the children of each classroom were taken at 9 a. m. and 1 p. m. The cause of absence was ascertained at a subsequent home visit. If a physician was in attendance, his diagnosis was accepted. If no physician was in attendance, the case was reported to the school physician who visited the home and made the diagnosis. Second, the record of respiratory affections in children attending school in the classrooms under observation was taken at 9 a. m. and 1 p. m. The pupil's explanation as to the cause was asked in each case, and recorded. These reasons were found to have little or no value. Each child was then inspected by the observer (nurse) to determine if any respiratory affection was present and, if so, its nature. The nature of these observations was confirmed by the physicians at frequent intervals and, for part of the study, were made by the physicians in each case. Frequent instructions as to standardizing diagnoses and repeated checking of the observations showed that the diagnoses were accurate and the observations thorough. Third, record of air conditions was made at eleven o'clock each morning and each afternoon at the end of the period of study immediately before aerating the room for the recreation period. All data were recorded under the following items: odor, temperature, moisture, air motion, air vents. The temperature was taken with the dry and wet bulb, with the sling psychrometer in the center of the room, about three to four feet from the floor, and the humidity was computed therefrom by standard methods.

School units, a unit being one school session, were used as the basis for the study and attached hereto are tables XI A and XI B showing the total registration units in each grouping, the total absence units from all causes in each group, the total absence units due to causes other than sickness, the total absence units due to sickness other than respiratory affections, total absence units due to respiratory sickness, and total respiratory sickness among pupils present in school.

There were 197,977 pupil session units in the 1916 study and 317,881 pupil session units in the study of 1916–1917. A study of Tables XI A and XI B shows that there were 506 more pupil session absences due to

TABLE XI A.

THE ACTUAL FIGURES FROM WHICH THE VARIOUS ABSENCE AND SICKNESS RATES AND PERCENTAGES HAVE BEEN TAKEN ARE GIVEN HERE IN PUPIL SESSION UNITS.

1916.

| | Entire group | Type A | Type B | Type C |
|---|---|---|---|---|
| Total registration units | 197,977 | 61,658 | 71,231 | 65,088 |
| *Total absence units from all causes | 12,381 | 3,653 | 4,492 | 4,236 |
| Total absence units due to causes other than sickness | 5,238 | 1,644 | 1,908 | 1,686 |
| Total absence units due to sickness other than respiratory | 4,835 | 1,354 | 1,856 | 1,625 |
| Total absence units due to respiratory sickness | 2,308 | 655 | 728 | 925 |
| Total respiratory sickness units among pupils present in school | 8,804 | 2,238 | 1,618 | 4,948 |

*There is a discrepancy in the figures showing total absences computed from the sum of the absences from each of the three causes and the total absence determined from the attendance and registration. The total absence units computed in the latter—indirect—manner are 3,669 for Type A, 4,588 for Type B and 4,340 for Type C. The total for the entire group is 12,597. There are thus 216 absences which do not appear in the foregoing calculations.

TABLE XI B.

THE ACTUAL FIGURES FROM WHICH THE VARIOUS ABSENCE AND SICKNESS RATES AND PERCENTAGES HAVE BEEN TAKEN ARE GIVEN HERE IN PUPIL SESSION UNITS.

1916–1917.

| | Entire group | Type A | Type B | Type C |
|---|---|---|---|---|
| Total registration units | 317,881 | 89,067 | 113,599 | 115,215 |
| Total absence units from all causes | 19,091 | 4,506 | 7,318 | 7,267 |
| Total absence units due to causes other than sickness | 8,872 | 1,972 | 3,521 | 3,379 |
| Total absence units due to sickness other than respiratory | 6,696 | 1,732 | 2,591 | 2,373 |
| Total absence units due to respiratory sickness | 3,523 | 802 | 1,206 | 1,515 |
| Total respiratory sickness units among pupils present in school | 23,255 | 6,667 | 5,374 | 11,214 |

The total absences from each of the three causes, computed from the sum of the absences from each of the three causes, corresponds with the number determined from the attendance and registration.

respiratory sickness in Type C (the mechanically ventilated classrooms at 68 degrees) than in Type B (the open window classrooms at 68 degrees) and 983 more pupil session absences due to respiratory sickness in Type C (the mechanically ventilated classrooms at 68 degrees) than in Type A (the open window classrooms at 50 degrees). Also, there were 7,257 more pupil sessions of respiratory illness occurring in pupils in attendance at school in Type C (the mechanically ventilated classrooms at 68 degrees) than in Type A (the open window classrooms at 50 degrees) and 9,170 more in Type C (the mechanically ventilated class rooms at 68 degrees) than in Type B (the open window classrooms at 68 degrees).

A study of Tables XII A and XII B shows that in absences from school of children who are ill with respiratory diseases, Type C (the mechanically ventilated classrooms at 68 degrees) has the highest percentage in both studies. Types A and B (the open window classrooms) show variation but in both instances are distinctly lower than in Type C. The percentages relative to respiratory sickness among pupils in attendance show wide variation between the same types in both groups and between the different types in each group. In both studies the percentage of children who had respiratory diseases but who were able to attend school is markedly greater in the Type C classrooms, ranging from 76.1 per cent in the 1916 study to 97.3 per cent in the 1916–1917 study. Type A shows the next highest percentage in both groups: 36.3 per cent in 1916 and 74 per cent in 1916–1917. Type B is markedly lower than either of the other two types: 22.7 per cent in 1916 and 47.3 per cent in 1916–1917.

It may be noted that the respiratory illness among pupils in attendance at school has been higher among the children of the Type A (open window classrooms at 50 degrees) than in Type B (open window classrooms at 68 degrees) while both remain lower than in Type C (mechanically ventilated classrooms at 68 degrees). As an explanation of the excess of respiratory sickness in Type A over Type B, attention is called to the factor of temperature of 50 degrees in Type A and 68 degrees in Type B. In this study the children under observation wore only their ordinary clothing, no extra wraps being provided. Both of these types were open window classrooms, the essential difference being in the temperature. It has been found by Miller and Noble, in a study of "The Effects of Exposure to Cold upon Experimental Infection of the Respiratory Tract" that "the weight of experimental evidence, including our own, does not justify the elimination of exposure to cold as a possible, though secondary, factor in the incidence of acute respiratory diseases."

It seems impossible to show any relation between the percentage of absence and the relative humidity and saturation deficit. In one instance, with a percentage of absence of 19, the relative humidity was 33 and the saturation deficit 5.33, while in the next class, with a relative humidity of 33 and a saturation deficit of 5.15, the percentage of absence was only 3.1. In the classes showing a high relative humidity, one with 73 showed only 3.5 per cent of absences while another,

## TABLE XII A.

## DATA ON CAUSE OF ABSENCE.

1916.

(Figures represent a rate per thousand possible pupil session units of registration.)

| | Absence from all causes | Absence due to causes other than sickness | Absence due to sickness other than respiratory | Absence due to respiratory sickness | Respiratory sickness among pupils in attendance |
|---|---|---|---|---|---|
| Entire group | 62.7 | 26.5 | 24.4 | 11.7 | 44.4 |
| Type A | 59.2 | 26.6 | 21.9 | 10.6 | 36.3 |
| Type B | 63.1 | 26.8 | 26.1 | 10.2 | 22.7 |
| Type C | 65.1 | 25.9 | 25.0 | 14.2 | 76.1 |

## TABLE XII B.

## DATA ON CAUSE OF ABSENCE.

1916–1917.

Figures represent a rate per thousand possible pupil session units of registration.)

| | Absence from all causes | Absence due to causes other than sickness | Absence due to sickness other than respiratory | Absence due to respiratory sickness | Respiratory sickness among pupils in attendance |
|---|---|---|---|---|---|
| Entire group | 60.0 | 27.9 | 21.1 | 11.1 | 73.1 |
| Type A | 50.5 | 22.1 | 19.4 | 9.0 | 74.8 |
| Type B | 64.4 | 30.9 | 22.8 | 10.6 | 47.3 |
| Type C | 63.0 | 29.3 | 20.6 | 13.1 | 97.3 |

## TABLE XVIII A.

## ANALYSIS OF EFFECT OF TEMPERATURE UPON RESPIRATORY SICKNESS.

1916.

Fifty-eight rooms, regardless of type, divided into three groups on a basis of temperature—Group 1, twenty coldest rooms; Group 2, next nineteen rooms and Group 3 nineteen warmest rooms.

| | Per cent of sessions | | | | Rate per 1,000 | |
|---|---|---|---|---|---|---|
| | Average temperature | 59 degrees and below | 60 degrees–69 degrees | 70 degrees and above | Respiratory absence | Respiratory in attendance |
| Group 1 | 59.1 | 52 | 46 | 2 | 10.4 | 42.6 |
| Group 2 | 66.6 | 4 | 78 | 18 | 8.2 | 58.0 |
| Group 3 | 69.8 | 0 | 40 | 60 | 15.8 | 68.0 |

with 76, showed 25.5 per cent of absences. Where the relative humidity was low, one class with 21 had an absence percentage of 6.8 while another with a relative humidity of 28 had an absence percentage of 31.0.

Tables XVIII A and XVIII B seem to show a causative relation between temperature and absences from respiratory sickness and number of pupils with respiratory sickness in attendance at school. It will be noted, however, that the average temperature given in Groups 1, 2 and 3 correspond very closely to the types of ventilation and in this view may be regarded as coincident factors, as may be seen in Tables XIX A and XIX B. In considering, however, the two factors—temperature and type of ventilation—the first, temperatures of Groups 2 and 3 have been shown to be closely related, while the second factor—type of ventilation—shows a marked difference, Type B, corresponding to Group 2, being the open window type of ventilation, while Type C, corresponding to Group 3, is the closed window, mechanical type of ventilation. The second factor, therefore, would seem to have had the greatest causative influence.

This investigation among 5,533 pupils in 76 classrooms in 12 schools operated under three different types of ventilation, conducted during a five-months period in the late fall, winter and early spring, forms the basis for the following conclusions:

1. In the closed window, mechanically ventilated type of classroom kept at a temperature of about 68 degrees F. the rate of absences from respiratory diseases was 32 per cent higher than in the open-window, naturally ventilated type of classroom kept at the same temperature (about 68 degrees F.) and about 40 per cent higher than in the open window, naturally ventilated type of classroom kept at a temperature of about 50 degrees F.

It was found, therefore, in this investigation, that children in classrooms with closed windows and ventilated by mechanical methods were more subject to respiratory diseases severe enough to keep them from school attendance than were children who were in classrooms kept at the same or lower temperature and ventilated wholly by open windows.

2. In the closed window, mechanically ventilated type of classroom kept at a temperature of about 68 degrees F. the rate of respiratory diseases occurring among pupils in attendance was 98 per cent higher than in the open window, naturally ventilated type of classroom kept at the same temperature (about 68 degrees F.) and about 70 per cent higher than in the open window, naturally ventilated type of classroom, kept at a temperature of about 50 degrees.

It was found, therefore, in this investigation, that children in classrooms with closed windows and ventilated by mechanical methods were more subject to respiratory diseases not sufficiently severe to keep them from school attendance than were children who were in classrooms kept at the same or lower temperature and ventilated wholly by open windows.

3. It was found in this investigation that the relative humidity of classrooms, whether ventilated by natural or mechanical means, was not a causa-

tive factor in the occurrence of respiratory illness among school children.

4. It was found in this investigation that the occurrence of respiratory diseases among school children was not influenced by sex.

TABLE XVIII B.

ANALYSIS OF EFFECT OF TEMPERATURE UPON RESPIRATORY SICKNESS.

1916–1917.

Seventy-six rooms, regardless of type, divided into three groups on a basis of temperature—group 1, twenty-six coldest rooms; Group 2, next twenty-five rooms and Group 3, twenty-five warmest rooms.

| | Per cent of sessions | | | | Rate per 1,000 | |
|---|---|---|---|---|---|---|
| | Average temperature | 59 degrees and below | 60 degrees–69 degrees | 70 degrees and above | Respiratory absence | Respiratory in attendance |
| Group 1 | 59.6 | 42 | 56 | 2 | 10.1 | 69.3 |
| Group 2 | 66.6 | 2 | 97 | 1 | 9.3 | 39.5 |
| Group 3 | 69.1 | 0 | 95 | 4 | 15.4 | 103.7 |

TABLE XIX A.

TYPE OF VENTILATION.

1916.

Number of rooms in each type

| | Type A | Type B | Type C |
|---|---|---|---|
| Group 1 | 17 | 3 | 0 |
| Group 2 | 1 | 10 | 8 |
| Group 3 | 0 | 8 | 12 |

TABLE XIX B.

TYPE OF VENTILATION.

1916–1917

Number of rooms in each type

| | Type A | Type B | Type C |
|---|---|---|---|
| Group 1 | 20 | 6 | 0 |
| Group 2 | 0 | 14 | 11 |
| Group 3 | 0 | 8 | 17 |

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